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ABSTRACT

Designed to serve as a resource tool in a high school vocational agriculture curriculum dealing with the environment as it relates to agriculture, this unit is concerned with plants. Plants are defined and their characteristics described. A section on the effects of environment on higher plants covers temperature, light, water, nutrients, air, chemicals and dust, smog, radiation, and sediment. The effects of pests on higher plants are discussed. Plants as sources of food, shelter, fiber, building materials, and other products are described. The effects of plants on the environment are treated from the points of view of esthetics, improvement of air, water, and soil, and reduction of noise pollution. A section looks at environmental problems of agricultural plants and forestry. A 27-item bibliography concludes the volume. (MS)

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Ag Ed Environmental Education Series

PLANTS

WASHINGTON STATE UNIVERSITY IN COOPERATION WITH THE COORDINATING COUNCIL FOR OCCUPATIONAL EDUCATION.

73-3F

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Environmental Education Series

- Air
- Agricultural Chemicals and Radiation
- Animals
- Land Use
- Noise
- Plants
- Understanding the Environment
- Water

ED 084422

PLANTS

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FOREWORD

This publication is the product of a project carried on by the Coordinating Council for Occupational Education and the Department of Education, Washington State University.

The project grew out of a recognition of the need to include as a part of the high school vocational agriculture curriculum information dealing with the environment, particularly as it relates to agriculture. The project was preceded by a period of growing concern that a body of factual information and teacher resources needed to be developed in this area.

E. M. Webb, associate professor of agricultural education emeritus, first suggested that steps be taken to make available to teachers of agriculture and their students factual information on the environment and agriculture. It was through the efforts of Jay Wood, program director, agricultural education, Olympia, that a project was prepared and approved beginning in September 1970.

Valuable assistance was given the project by many persons from the following agencies: Washington State University, University of Washington, Western Washington State College, Soil Conservation Service, United States Department of Agriculture, United States Department of the Interior, Washington Parks and Recreation Department, Washington Department of Ecology, Washington Department of Natural Resources, Washington Department of Agriculture, Washington Department of Fisheries, Washington Water Pollution Control Commission, Environmental Protection Agency, and Washington Department of Game. Many other agencies provided information for the project.

Three publications were extremely useful in preparing this unit. They were *Environmental Quality: The First Annual Report of the Council on Environmental Quality*, *Environmental Quality: The Second Annual Report of the Council on Environmental Quality*, and *Wastes in Relation to Agriculture and Forestry*. Information from these publications was used as a basis for much of this unit.

Grateful acknowledgment is hereby made to the following groups of people: Dr. C. O. Loreen and Dr. Keith E. Fiscus, both teacher-educators and state supervisors in agricultural education, and Mr. Jay M. Wood, program director, agricultural education, who gave able assistance to this endeavor. Mr. William Dellos, Mr. George Jungel, and Mr. E. W. Teesdale, teachers of agricultural education in Washington high schools, reviewed the unit, developed teaching materials to be used with the unit, and taught the unit to their students. Many other teachers also made valuable contributions to the project.

The following subject-matter specialists reviewed the unit: Dr. David Baumgartner, extension forest resource specialist, Washington State University, and Dr. Doyle Smittle, assistant professor of horticulture, Washington State University.

This unit is one of eight being produced under the project. The other seven include: *Understanding the Environment*, *Water*, *Noise*, *Agricultural Chemicals and Radiation*, *Animals*, *Land Use*, and *Air*.

July 1972 — Rodney W. Tulloch

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PLANTS AND PLANT CHARACTERISTICS

In order to discuss plants intelligently, we should understand what a plant is. When we think of plants we often think of trees, field crops, flowers, or vegetables and may completely forget bacteria and fungi. A good place to start then might be with a definition.

What is a Plant?

A plant, according to *Webster's Seventh New Collegiate Dictionary*, is "any of a kingdom (Plantae) of living beings typically lacking locomotive movement or obvious nervous or sensory organs and possessing cellulose cell walls." The plant kingdom is divided into four phyla: the thallophytes, bryophytes, pteridophytes, and spermatophytes.

Thallophytes

Thallophytes are the simplest form of plants. Many have only one cell. Thallophytes lack true stems and leaves and do not produce flowers or seeds. Bacteria, algae, fungi, and lichen are the four subphyla of thallophytes. Algae can manufacture their own food since they contain chlorophyll. Algae have not been considered as having great economic importance up to this point, so they have had little effect on farming. Possible uses for algae will be discussed later.

Fungi do not contain chlorophyll and do not produce their own food. Fungi are of economic importance in agriculture as they cause plant diseases such as rots, rusts, blights, wilts, and smuts. Fungi also serve some useful purposes such as mushrooms.

Bacteria are important to agriculture in many respects. They help decay straw, manure, and crop refuse. The breakdown of these materials releases plant nutrients that can be used by growing plants. Some bacteria live in nodules on the roots of legume plants (alfalfa, clovers) where they remove nitrogen from the air and convert it to forms that eventually can be used by other plants. Bacteria are involved in preservation of silage, in curing of cheese, and in other fermentation processes. Bacteria also cause many diseases.

Bryophytes

The bryophytes include mosses and liverworts. They do not have true leaves or stems and reproduce by means of spores. They have little direct economic effect on agriculture.

Pteridophytes

The pteridophytes produce true leaves and stems and reproduce by means of spores. Included in this phylum are ferns, horsetails, and club mosses. They have not been of great importance to agriculture.

Spermatophytes

The spermatophytes are the highest form of plant life and include flowering or seed-bearing plants. These are divided into two subdivisions: Angiospermae and

Gymnospermae. Gymnosperms include cone-bearing plants such as cedars, spruces, pines, hemlocks, and firs. This group of plants has great importance to agriculture and will be discussed throughout the unit.

Angiosperms are called the flowering plants and are divided into two classes based on the number of seed leaves (cotyledons). A plant with a single seed leaf is called a monocotyledon ("mono" means one) and a plant with two seed leaves is called a dicotyledon ("di" means two). "Monocots" include the grass family, which includes small grains (wheat, oats, barley, rye), corn, quack grass, bluegrass, brome grass, timothy, and the millets.

"Dicots" include the legume family (clovers, alfalfa, peas, beans, and peanuts). Some other dicots are cotton, potatoes, and buckwheat. Obviously, these plants are of extreme importance to agriculture.

Photosynthesis and Respiration

Much of the discussion in this section has been taken from "Trees," *1949 Yearbook of Agriculture.* If you are not already familiar with photosynthesis and respiration, it is suggested you get a biology or botany book and study these processes in some detail.

Let us consider first the process of photosynthesis—that is, building with the energy of light. In this process, organic matter is formed literally from thin air and water. The air contains minute amounts of carbon dioxide (0.03% by volume or three parts in 10,000 parts of air). Through millions of small pores, or stomata, on the leaf surfaces, air penetrates the leaves and gives up about 10% of its meager supply of precious carbon dioxide to the plant. In the leaf cells are found small particles called chloroplasts; these contain a green substance, chlorophyll, similar in structure to the hemoglobin of the blood. In fact, in reflected light chlorophyll appears not green but blood red.

Carbon dioxide unites with the chlorophyll, and, in a chain of reactions regulated by the enzymes, it combines with the oxygen and hydrogen in water to form sugar. An excess of oxygen is released in this process. The energy needed for transformation of carbon dioxide and water into the organic substance (sugar) is supplied by sunlight. Only about 1% of the solar energy that falls on a leaf is used for photosynthesis. The sugar formed in the process of photosynthesis is dextrose. From it, 95% of the body of the plant is ultimately made by a series of complicated reactions. Dextrose may be converted into other sugars or it may be combined with nitrogen to form the amino acids, the building blocks from which proteins are made and on which all life, both plant and animal, depends. Part of the dextrose is also used for other purposes, such as conversion into starch, fats, and other substances.

The most favorable conditions for photosynthesis are mild temperatures (about 70° F) and diffused, moderate light. On hot, bright, summer days the efficiency of photosynthesis goes down. An ample supply of water is essential. When the soil is dry and not enough water is delivered to the plant, the rate of photosynthesis declines. Fertility of the soil is also important, for the building of the plant requires an ample supply of mineral elements.

Respiration is another life process. Like other living organisms, a plant must respire. The process of respiration consists of oxidizing (burning at low temperature) dextrose sugar; although some energy is lost as heat, most of the energy released during the process is used by the organism for its vital processes. Thus, sugar is a source of energy for a plant just as it is for a football player. The chemical reaction of respiration is a reversal of the chemical reaction of photosynthesis, as seen from the following scheme:

Photosynthesis:

Carbon dioxide	+	water	+	energy expended	→	dextrose	+	oxygen		

Respiration:

Dextrose	+	oxygen	→	carbon dioxide	+	water	+	energy released		

In daytime, both photosynthesis and respiration occur at the same time. Oxygen liberated in photosynthesis is used for respiration, while the carbon dioxide exhaled by the plant is used in photosynthesis. As photosynthesis is a more intensive process than respiration, during a normal day, an excess of oxygen is eliminated and an excess of carbon dioxide is absorbed by the plant. When, under adverse conditions, daytime respiration is more intensive than the body-building photosynthesis, the plant loses weight instead of gaining. At night, because of the absence of light, photosynthesis is at a standstill, but respiration continues—just as in humans, oxygen is taken in and carbon dioxide is eliminated. Respiration is going on at all times in all living cells, in the leaves, the roots, and in the stem and bark.

While photosynthesis is optimum on cool days and decreases when the weather becomes too hot, respiration does not have such an optimum. The warmer it gets, the more intense is the respiration. Respiration is less sensitive to the lack of water than photosynthesis; that is why, during droughts, when photosynthesis stops, respiration still continues and causes great harm to the plant. Inside temperatures of 120° to 130° F will kill a tree.

Specialized Systems of Higher Plants

Various parts of plants carry on somewhat specialized processes necessary for continued plant growth and production.

Leaves

Leaves of many plants are green, and all higher plants contain chlorophyll. A primary function of leaves is to expose chlorophyll to the sun so that photosynthesis can take place. Leaves also store plant food and water and allow water vapor to escape or to some extent hinder its escape. This loss of water through the leaves can be controlled somewhat by the plant. In hot, dry weather corn rolls its leaves up so that less surface is exposed allowing less evaporation.

The amount of evaporation that takes place from a plant's leaves may have an important effect in that the plant may remove nutrients from the water that passes through it. Plants seem to have the remarkable ability of getting much of what they need from what is available.

Leaves vary greatly in size, shape, and composition. Some leaves, like those of the palm tree, are large while others, like the needles of pine trees, are small. The narrow needle-like leaves of the pine tree also contrast with the broad leaves of the tulip tree. Some (like the leafy vegetables spinach and lettuce) are juicy and crisp while others are rather tough and wiry like pine needles. Some leaves are smooth and covered with a wax-like material, such as a begonia, while others have a hairy covering like thistles. Such variety allows plants to thrive in many different conditions.

Roots

Roots are often the major absorber of liquids for the plant, so one goal in plant breeding is to develop larger root systems (fig. 1). The roots may also store food as in the case of carrots and radishes. They usually anchor the plant and often hold the plant erect. Although roots more commonly are thought to grow in soil or water, some grow on top of the ground. The hanging roots of some orchids take water from the air. Roots of legume family plants serve as hosts for bacteria that take nitrogen from the air.


USDA Photo

Fig. 1.—New varieties often have larger root systems.

Roots may cover a rather large area. Corn plants 7 inches high may have roots that have already met roots of a similar plant 20 inches away. At full growth, a corn plant's roots may cover an area 4 feet square at the surface and go 8 or more feet deep. The total length of root hairs of a winter rye plant may be more than 5000 miles.

It is common for grass roots to grow a 1/2 inch per day, and, under vigorous growing conditions, it is possible for them to grow 2-1/2 inches per day for a few weeks. Such growth allows the plant to take up water and nutrients from a large volume of soil. An advantage of many hybrid plants is that they have larger and often deeper root systems. Along much of the root system of most plants are found small root hairs that actually take in most of the water and nutrients.

Plants whose roots grow in water do not have root hairs. Some evergreens do not have root hairs but take in water and nutrients through fungi that grow around the roots. The fungi receive some food from the plants on which they grow. Thus, they have a mutually beneficial relationship.

Stems

Stems are another important part of the plant. If you cut the stem of a plant, the leaves and any flowers usually wilt rapidly, but if you cut a stem and then put it in water, it will usually hold up much longer. We can see that the stem has the ability to carry some of the needed water to the leaves and flowers. Roots and leaves also move liquids around in the plant. This is done through what we could describe as small tubes. Xylem is the name given to the part of the transport system that moves water and nutrients from the roots to other parts of the plant. Phloem is the name of the part of the transport system that moves food (sugars and starches) from the leaves to other parts of the plant.

Stems may contain chlorophyll and can carry on photosynthesis. The stem may store food and be the important part of the plant economically as is the case of the potato, which is a modified stem. The eyes, however, are buds. The stem may be hard to find as in the cabbage or lettuce or be conspicuous like the trunk of a tree that has lost its leaves in winter. Stems also may vary widely in composition. Some may be very hard and are called woody. Other stems are not woody and are called herbaceous. Woody stems will usually survive physical punishment better than herbaceous stems.

EFFECTS OF ENVIRONMENT ON HIGHER PLANTS

Many environmental factors affect plant growth. Since our goal in producing most plants is high production, it is reasonable to select a suitable environment for the plant or try to modify the environment.

Temperature

Temperature is one of the most important factors affecting plant production. Plants vary widely in their ability to adapt to or cope with temperature. The effect of temperature may be tempered or exaggerated by a combination of many of the other factors discussed in this section. Plants can be put into temperature groups that will indicate whether they do better in cool or warm weather. It can also be pretty well predicted in what areas certain kinds of plants can be expected to live.

Temperature has been shown to greatly affect the rate of growth of many plants. The quality of product can be changed greatly. Extremes in temperatures almost always result in a reduction of quantity and quality of plant production. Extreme temperatures like 50° or 100° F during the pollination period can lower pollination in plants like tomatoes. Cool weather over a period of time can force biennials to produce seed stalks the first year—a disaster for such vegetable crops grown for market as beets, celery, cabbage, and lettuce.

Temperature can also have an important effect on photoperiod response (explained further under "light," below).

Temperature and its effects can be modified by many factors. The location in relation to the equator is one important factor. Breezes off bodies of water tend to moderate the temperature by cooling in the summer and warming in the winter. Other winds may make the high summer temperatures more driving and the low winter temperatures more killing. Geological formations may affect weather in general and may have an effect of several degrees between a valley and a ridge nearby. Elevation may make a great deal of change in temperature. The exposure to the sun also makes a great deal of difference in temperature as can be illustrated by how fast snow melts on various sides of a hill.

Light

A minimum amount and intensity of light is required before a plant can carry on photosynthesis and stay alive. Besides affecting growth, light may also affect the flowering of plants. Many long summer days produce more energy than most plants can use efficiently because other factors are limiting their growth. Natural light is not adequate for rapid growth of plants during the wintertime and is a limiting factor in much greenhouse production.

The effect of length of day on growth and blooming is referred to as photoperiodism. Many vegetables and flower plants can be divided into three groups based on their response to length of day. Some plants, such as asparagus, cucumber, pepper, snap bean, and tomato, are not greatly affected by length of day. The sweet potato blooms during short days and is called a short-day plant. Long-day plants include beets, dill, lettuce, radishes, and spinach. Long days are generally considered to be about 12 to 14 hours while short days are from 8 to 10 hours.

Water

Plants, like animals, are made up of a large percentage of water. Both soil moisture and humidity (water vapor in the air) affect plant growth. In some areas, water is transported great distances for use by plants (fig. 2). Water is not only an important substance itself, it also serves the plant for other purposes.

Water serves as a solvent for many different substances. Once many of these substances are dissolved or are in suspension in water they can be carried into plants. Water is, therefore, very important in the transportation process. Even within the plant many materials are moved from one place to another in the medium of water. Water also helps to move materials through the soil.

Washington State Game Department Photo

Fig. 2.—Canals may carry water for many miles so that crops can be irrigated.

A large percentage of the matter in living cells of plants is water. Water is also involved in many of the important chemical reactions that take place within a plant. Although the amount of water required by a plant may vary considerably, depending on the type of plant, all plants need water. Water vapor in the air may collect many soluble materials that can then be carried into a plant.

Water applied to plants can contain salts or pesticides that can damage plants. Such problems are discussed in more detail in the unit on water.

Inorganic salts and minerals may also have an effect on plants. Inorganic salts and minerals become particularly important in irrigated areas where water containing these materials is added to the soils and evapo-transpiration consumes the water, leaving the salts behind. If irrigation is improperly handled, it may virtually eliminate future crop production on these areas. The normal procedure is to apply more water than is actually necessary for the crop's use. This water than leaches the salts to deeper levels where they will not interfere with crop production.

Nutrients

Another necessity for plant life is plant nutrients. For years people have used the little saying, "C. HOPKNS CAFE, mighty good, bring mine cousin Mo," to help them remember the major and minor elements. These elements, as listed in this little reminder, are carbon, hydrogen, oxygen, phosphorous, potassium (K), nitrogen, sulfur, calcium (Ca), iron (Fe), magnesium (Mg), boron (B), manganese (Mn), zinc (Zn), and molybdenum (Mo). The amounts of these plant nutrients necessary for plant growth depend upon the type of plant and growing conditions.

Some of the minor elements may cause great damage if applied too heavily. An overabundance of one of these elements may actually make another element unavailable for plant use. Certain combinations of these elements may be undesirable while other combinations are highly desirable. Certain combinations may form acids or salts that may be highly detrimental to plant growth. Since water acts as the means for transportation of these elements into a plant, it, as well as the nutrients, must be present for the plant to be properly nourished.

Some of the common ways of adding nutrients to the soil are through fertilizers and green and animal manures. Fertilizers have become, by far, the leading method in recent years (fig. 3). The major elements or nutrients in fertilizers are stated in the following terms. Nitrogen is usually given just as N (nitrogen). Phosphorous is given as P_2O_5 (phosphoric acid). Potassium is given as K_2O (potash). Of these three, nitrogen is by far the most likely to leach (be washed from) the soil.

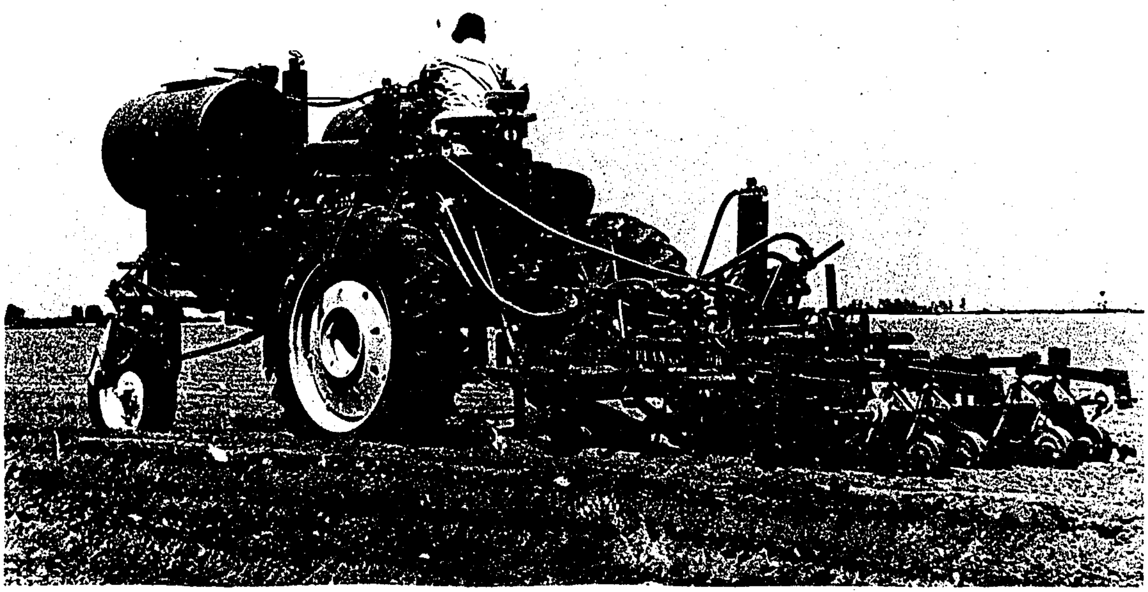

USDA Photo

Fig. 3.—Fertilizers may be applied as part of the planting operation.

Soils vary greatly in the amount of nutrients they contain and their ability to retain nutrients even when they are added. Some soils hold on to nutrients so tightly that they are not available for use by plants.

Plant nutrients affect plant growth; their amounts and availability to the plants may strongly influence the types of vegetation that exist in an area. As nutrient levels in lakes and streams increase, the process of eutrophication (dying of lakes), which is a natural process, is speeded up. This is one undesirable effect of plant nutrients. Excess quantities of nitrogen may cause grain plants to grow taller and weaker and greatly increase lodging (falling or lying down). Plant breeding and selection has overcome some of this problem.

Air

Air has an effect on plants and plant growth. Many elements are removed from the air by plants. These include carbon, hydrogen, oxygen, and nitrogen. Some of these elements may be taken up by the plant in elemental form or in combinations of elements as radicals or compounds. Water, one of the compounds, is extremely important.

Carbon dioxide (CO_2) is taken up by plants during photosynthesis and oxygen is released. Carbon dioxide makes up only about 0.03% of the earth's atmosphere. This very small percentage, however, is a source of carbon—an important material for life.

Oxygen, on the other hand, may be taken in directly in the elemental form. There are some lower plant forms that grow better without oxygen and may even be killed in the presence of oxygen. The atmosphere contains about 20% oxygen by volume. Oxygen is a gas that dissolves in water and is therefore available to aquatic plants.

Nitrogen is the most common element in the atmosphere, being nearly 80% by volume of the atmosphere. Only a few very simple plants such as bacteria are able to directly use nitrogen from the atmosphere. Of much more importance to agriculture are the bacteria that live in nodules on the roots of legume plants. These legume plants, such as alfalfa, clovers, and beans, remove nitrogen from the air and store it in the nodules on the roots. As these plants decompose, nitrogen is released into the soil and may be used by other plants or animals. Raising legumes is a natural way of removing nitrogen from the air for other uses. Nitrogen can also be removed from the air in rainfall. On the average, approximately 5 pounds of nitrogen are added per acre to the earth's surface with rainfall annually. This amounts to about 5 million pounds in the continental U.S.

Chemicals and Dusts

Air may carry volatile chemicals and dusts that contain pesticides and herbicides. Thus, a herbicide, for example, which may have been applied many miles away, can be deposited on a crop highly sensitive to this type of herbicide with possible disastrous results. If insecticides were deposited on a crop in which the leaves are eaten, such as lettuce, the crop could be rendered inedible by the accumulation of these insecticides. Just the accumulation of dust on a leafy vegetable such as lettuce may considerably lower the quality. Fruits may also be damaged by an accumulation of dust.

Accumulations of dust on leaves cut down on the amount of sunlight reaching the leaf. As sunlight is cut down, photosynthesis is interfered with. Dust accumulations may also affect the leaf stomata that permit gas exchange between the leaves and the surrounding atmosphere. When these processes are interfered with, the growth of the plant is retarded. Dust that accumulates on greenhouses may cut down the amount of light available inside the greenhouse and may thus interfere with plant growth. This is a particularly serious problem in the wintertime when there is less sunlight available.

A dust-carrying windstorm can completely destroy a stand of young plants (fig 4). The dust beating against the plants is very similar to sand blasting. Considerable amounts of wind-blown dust damage occurs in the Atlantic coastal plain. Serious damage to young plants has also been recorded in Midwestern States.

USDA Photo

Fig. 4.—Great dust storms do enormous amounts of damage.

In addition to natural dusts, industrial pollutants may have severe effects on plants. Although dust from natural sources, from agricultural sources, and from highway and industrial construction do considerable damage, certain industrial types of pollutants may be even more serious. For example, certain mining operations such as strip mines, mineral processing operations such as cement plants, and fly ash from filters may have severe consequences. Sulfur dioxide from metal smelting plants may severely damage many types of crops and forests. However, there is less likelihood today of the dramatic type of plant damage that has been seen near smelters and other industrial operations in the past. This is due mainly to improved laws and increased enforcement as well as better understanding and better equipment being used by industrial concerns.

Smog

Smog in the Los Angeles area has contributed to a slow decline in the number of citrus groves south of the city. San Bernardino National Forest, 50 miles away, has also received damage. Fluorides and sulfur oxides produced by phosphate fertilizer processing plants have been known to damage a large number of various types of vegetation. Livestock grazing on vegetation covered with fluorides may develop a crippling condition known as fluorosis. New Jersey has had smog injury to vegetation reported in every county, and damage has been reported to at least 36 commercial crops. Ozone, one of the major photochemical oxidants, has damaged a wide variety of plants. Long-term ozone exposure to even as little as 0.05 part per million can reduce radish yields by as much as 50%. Another important agriculture crop, tobacco, is sensitive to ozone at even smaller levels.

Radiation

Another area of the environment that is detrimental to plants is radiation. Plants may absorb radiation both from the soil and from radioactive fallout. Phosphate rock, which is used for making phosphate fertilizers, sometimes may contain traces of uranium-238. Fortunately, uranium is not readily absorbed by plants. Uranium as it decays gives off the following as some of its products of decay: radium-226, radon-222, lead-210, and polonium-210. These elements may be absorbed by plants or they may simply settle as dust on plant tissue. Up to the present time, radioactivity in phosphate fertilizers has not been a significant threat, but it should be checked on in the future.

Certain crops have tendencies to accumulate higher levels of radioactive materials than other crops. It is reported that tobacco leaves can accumulate appreciable levels of polonium-210. The level accumulated varies with the location, culture, type of tobacco, and curing method. With tobacco, the problem becomes one of even greater concern since polonium-210 volatilizes at the temperature of tobacco combustion. Therefore, it may be inhaled by smokers and has been suspected of being one of the factors that results in a greater incidence of lung cancer in persons who smoke.

Another important aspect for farmers is the possibility of farm products being confiscated for radioactivity. Milk has been confiscated on the basis of radioactivity, and it is likely that other products could also be confiscated if radioactivity increases. Since feed for livestock might have to be transported a considerable distance if plants in a certain area are contaminated with radioactivity, it becomes obvious that the cost would be very high. The potential importance of radioactive fallout, to farm economics, and even more importantly to human and animal health, demands that more research be done to find out all the effects of fallout on plants so that better predictions of effects on humans and animals can be made.

Sediment

Sediment has been both good and bad for crop production. The Valley of the Nile is a good example of sediment being used to grow better crops than otherwise would have been possible. Partly the effects of sediment depend on the types of materials deposited. If they are very low in nutrients, production may decrease. If they are clays or silts and contain much higher amounts of nutrients, they may be beneficial. The depositing of sediment may completely destroy a crop. Since sediments must come from someplace they often leave the area from which they are taken in quite a devastated condition.

EFFECTS OF PESTS ON HIGHER PLANTS

Most plants are bothered by some pests. The three major categories of pests are weeds, insects, and diseases. A rather thorough discussion of the control of these pests is carried out in the unit: *Agricultural Chemicals and Radiation.*

Weeds

Weeds are sometimes defined as plants with a negative value as found. Weed seeds are transmitted by wind, soil, water, birds, and animals. Weeds can be just as harmful to a crop as insects or diseases and are, therefore, an important consideration. Wind is a most important spreader of weed seeds and carries them to many millions of acres each year. When water containing weed seeds is used for irrigation, weed seeds may be spread through many acres. Spreading manure, particularly when it is high in bedding material, may spread weed seeds.

Many weed species are poisonous to livestock, birds, wildlife, and humans. Several weed species also have poisonous seeds. Farmers spend approximately \$2-1/2 billion annually to control weeds. Even with these high expenditures it is estimated that crop yields and quality are reduced from 3% to 25% each year, depending on the crop. This reduction in yield can have just as serious consequences in human deaths from starvation as would be caused in human suffering and death from the transmission of scarlet fever.

Ragweed, goldenrod, Bermuda grass, and a host of other weeds produce pollens and toxins that cause serious human allergies. Allergens are also produced by walnut trees and other economically important plants and trees. The production of these pollens and toxins is great enough so that with the wind to carry them they affect most of our heavily populated areas. These allergens reduce working efficiency, cause severe suffering, and impair health as well as increase medical costs. The Public Health Service estimates that there are more than 12-1/2 million sufferers from asthma and/or hayfever each year. Pollen is responsible for three-quarters of the approximately 5 million asthma sufferers. The more than 7-1/2 million remaining suffer from pollen allergies. Over 10 million workdays are lost each year. At a minimum rate of \$10 per workday that is over \$100 million lost each year. Losses of production capacity in industry would make this figure even more severe. Poison ivy, poison oak, and other poisonous weeds cause nearly 2 million cases of skin poisoning each year. This results in approximately 330 thousand lost workdays or another few million dollars in wages. Some persons suffering from such skin poisonings may be able to work, but they may still suffer from decreased productivity or be restricted in their activity.

Pollen-caused allergies have become much more noticeable in recent years. This may be due in part to the combination of these pollens with other air pollutants. It is theorized that another reason that these are becoming more widespread is the increase of "natural areas" such as parks, campsites, and other rural recreation areas.

Insects

It is estimated that the weight of all insects is greater than all land animals combined. Insect pests damage plants as well as harvested plant products (fig. 5). On the average,

Clemson University Extension Service Photo by L. Riley

Figure 5.—Closeup of a boll weevil on a cotton plant.

insects destroy about 10% of all crops in the United States. Losses in limited areas may reach as high as 90% to 100% for certain crops. These losses from insects amount to billions of dollars of damage each year.

The type of damage done and the best method of control for insects that attack plants depends on the class of insects. There are four major classes of insects. (1) Chewing insects chew plants and can be controlled through the use of stomach poisons. Examples of chewing insects are the Colorado potato beetle and grasshoppers. (2) Sucking insects pierce the outer layers and suck the sap out of the cells of plants. Examples are aphids and leafhoppers (fig. 6). Sucking insects can be controlled by contact poisons. (3) Internal feeding insects get in a plant and feed from within. Examples are the European corn borer and wheat joint worm. Internal feeding insects are difficult to destroy when they are inside the plant, except through the use of systemic insecticides, which are transported from one part of the plant to another. In some cases, fumigation or treating the insect during the part of the cycle when it is outside the plant is the best means of control. (4) Subterranean insects attack plants below the soil surface. Examples are the white grub and wire worm. The most effective means of eliminating subterranean insects is with the use of chlorinated hydrocarbon insecticides such as Aldrin, heptachlor, Dieldrin, Lindane, and Chlordane. For a discussion of these chemicals see the *Agricultural Chemicals and Radiation* unit.

USDA Photo

Fig. 6.—Alligator-like larva of the lady beetle eating an aphid. Other aphids can be seen on the plant stem. A common predator of many injurious insects, the lady beetle may consume 300 to 400 aphids before changing to the pupal stage.

Although there has been much talk about alternatives to using insecticides (fig. 6 shows an example of biological control), most of the experts agree that there will be a considerable need to use pesticides in the foreseeable future. Unfortunately, the use of some insecticides may kill beneficial insects such as bees and other insects that are useful in pollination.

Another concern of many people who are working in ecology is that of biological magnification, which may take place in fat-soluble pesticides. For example, if DDT is sprayed on trees, some of the spray will likely be absorbed into the soil below. Earthworms living in the now contaminated soil will pick up the DDT and may then be eaten by robins. As robins eat a number of these contaminated earthworms, they accumulate higher and higher quantities of DDT and may be killed. (For a more thorough discussion of insects and insecticides, see the units on *Animals* and *Agricultural Chemicals and Radiation.*)

Although the largest losses by insects to plants and plant products occur during the growing stages, much damage is also inflicted by insects upon stored plant products. Not only can insects lower the weight, they can also lower the value of the product for food or even make it unusable as food. Insect injury in small grains may include a great reduction in germination of the seed for use in planting the next year's crop. The insects may also leave behind excrement, insect parts, or whole dead insects to further depreciate the value of the grain. In surveys, wheat in untreated storage bins has been found to contain as much as 3 million or more insects per 1000 bushels of wheat. Control of such insects as the rice weevil, grainery weevil, and grain moth starts with a good sanitation program. Harvesting equipment and storage facilities are cleaned thoroughly and sprayed or dusted as a final assurance that insects have been killed. Once the grain is in storage it can be treated by fumigation to protect it from insects or to kill those already present.

Fig. 7.—Insecticides, fungicides, and herbicides are increasing production and efficiency in many crops.

Diseases

The United States Department of Agriculture estimates that nearly $3 billion worth of damage is done to crops each year through plant diseases. Almost 7% of the average yield of crops is lost because of damage from plant diseases. Important plant diseases include blights, rusts and smuts, mildews, and wilts. There are literally hundreds of plant diseases that lower the yield and quality of crops. Bacterial wilt of alfalfa has greatly reduced stands of this crop. Black stem rust in small grains shrivels the kernels and reduces the yield. Ergot replaces the kernel in rye, and the hard black substance remaining is poisonous to livestock and to humans. Blight causes severe losses in many crops but has caused particularly severe famine by destroying such crops as potatoes. These diseases, along with numerous others, center their attacks mainly on growing plants.

Stored plant products are also subject to many plant diseases. One of the most important losses occurs from mold in stored small grains. This is particularly prevalent when the grain is stored at too high a moisture content, or when the grain is attacked by certain insects.

Plant diseases caused by pathogens (specific sources of diseases) fall into three main categories: fungi, bacteria, and viruses. Fungi are parasites that are the cause of a large number of rapidly spreading diseases. These true plants reproduce by spores that are produced in large numbers under favorable conditions and can spread rapidly and widely. Examples of diseases caused by fungi include: late blight, scab, mildew, and smut of potatoes; stalk, ear, and root rot of corn; and rusts, smut, and ergot in small grains.

Bacteria are smaller parasitic plants than fungi. Bacteria are small enough to enter many small, natural openings in plants such as the stomates. These small plants reproduce through cell division. As they divide, one becomes two, two become four, four become eight, and so on. Under advantageous growing conditions, they can divide three times in an hour and thus increase very rapidly. Examples of diseases caused by Bacteria include: halo blight in small grains, black chaff rot of wheat, black leg and ring rot of potatoes, and bacterial wilt of alfalfa and corn.

Viruses are a third major cause of plant diseases and may be carried by insects like aphids and leaf hoppers. Examples of diseases caused by viruses include: rosette and streak mosaic in wheat; leaf roll, mosaic, and spindle tuber in potatoes; mosaic in beans; and curly top of sugar beet, beans, tomato, and pepper.

Malnutrition may also cause diseases. Lack of minor and trace elements, an imbalance of elements, or physiological disturbances may cause diseases. Physiological disturbances may be caused by unfavorable soil and/or climatic conditions. Examples of such diseases are: yellow berry of wheat, leaf spot and oat blast in small grains, heat rot and dry rot of beets, and frost injury and chlorosis in many crops.

Because different plant diseases have different life cycles and methods of reproduction, various methods of control need to be used. One method of control is exclusion. This is carried out through the use of quarantine to keep infections from being spread from one place to another. A second method of control is irradication. One effective means of irradication is to destroy alternate hosts that help diseases over winter or through other periods of their life cycles when the regular host crop is not available. Another method of control is that of careful selection of seed, choosing only seed that is disease free. This is done particularly with potatoes where one potato from a hill is planted, grown, and then observed for selection purposes before the rest of the potatoes from the hill are planted.

Plant diseases can also be controlled by certain methods of protecting the crop. For example, careful planning of crop rotation and crop sequence can help to avoid raising plants in successive years that will be attacked by the same pathogens. This is particularly true in soil-borne diseases that, without a plant to attack, may be eliminated or at least drastically reduced. In some cases, harboring materials such as straw or stubble may be removed or destroyed, thus eliminating the pathogens causing the disease. Some pathogens are carried on the seed and may be killed by seed treatment. Although very expensive, fumigation is a practical means of controlling soil fungi in high-income crops. Another means of protecting plants from fungi is to spray or dust them with fungicides (fig. 7).

Another method of controlling plant diseases, and one of the only practical ones for some situations where the disease cannot otherwise be controlled, is the development of a resistant variety. Finding a variety that is resistant to any specific disease may be a very time-consuming job. The variety is not always easily found to have all of the attributes that are needed. The United States Department of Agriculture and State Experiment Stations continue to look for improved varieties and other methods of fighting and controlling plant diseases.

PLANT PRODUCTS

Plants are an efficient source of many types of products. Since plants can be grown over and over, they can be considered a renewable resource. Thus, products from them are not limited at a set quantity as are mineral resources like gold and oil.

Plants as Sources of Food

Throughout history man has had to struggle to find sources of food. Large populations have been wiped out in many parts of the world due to famine. Through the years, crop failures have often meant sure starvation for large numbers of people. In Biblical history, we can read of Joseph's brothers returning to Egypt to get food because of the famine. Through the years, man developed better methods of agricultural production. Many of these methods increased yields, and some increased man's ability to prevent losses from natural hazards. Even with the improved methods, famine was not defeated. For example, by the middle of the 19th century, potatoes became the major food crop in Ireland. Then, in 1845 and 1846, the potato crops were almost completely destroyed by potato blight. Because of the lack of food, and therefore malnutrition and the diseases that accompany malnutrition, approximately a third of the Irish population died. An even greater number of Irish were able to immigrate, however, thus keeping the problem from being more severe.

Unfortunately, famine has still not been licked. As late as 1943, a large-scale famine was reported in India. Somewhat lesser famines have occurred often since then. Due to a crop failure, the food situation was very serious, but to make matters even worse, imports of food supplies were decreased due to the war. Estimates are that at least a million and a half people died from the famine and the diseases that followed.

According to estimates of the United Nations, the world's population may double between the years 1965 and 2000. This estimate is based on many factors that are subject to change. The doubling of the population will require a doubling of food supplies if the population is to continue to eat the same amount and kind of food per capita. Unfortunately, many persons at present are not receiving adequate diets. Therefore, if such an increase in population takes place and if people don't eat less, and if all persons are to receive an adequate diet, an even greater increase than doubling of food production between the years 1965 and 2000 will likely be necessary. Better distribution of food and population could ease some of the problems.

The amount of area suited to the production of food crops is not evenly distributed throughout the regions of the world. Furthermore, many of the regions of the world are suited only to particular kinds of food crops. A number of factors are involved in the distribution of food plants. They include the following: temperature, moisture, light, topography, soil, air movements, and economic and social factors.

In many areas of the world, particular crops have been looked on with considerable favor as staple foods (fig. 8). These staple crops are mainly grains and root crops. Some of the more important grains are wheat, rice, corn, oats, and barley. In root crops, potatoes and sweet potatoes head a long list of foods used for human consumption. Various societies have preferred certain of these staple crops over other crops even when more than one could be grown in their area. Some of these preferences seem to be due to historical and cultural customs. In other cases, the types of foods that can be obtained are due largely to mechanisms of trade.


USDA Photo

Figure 8.—Plants provide us with many kinds of foods.

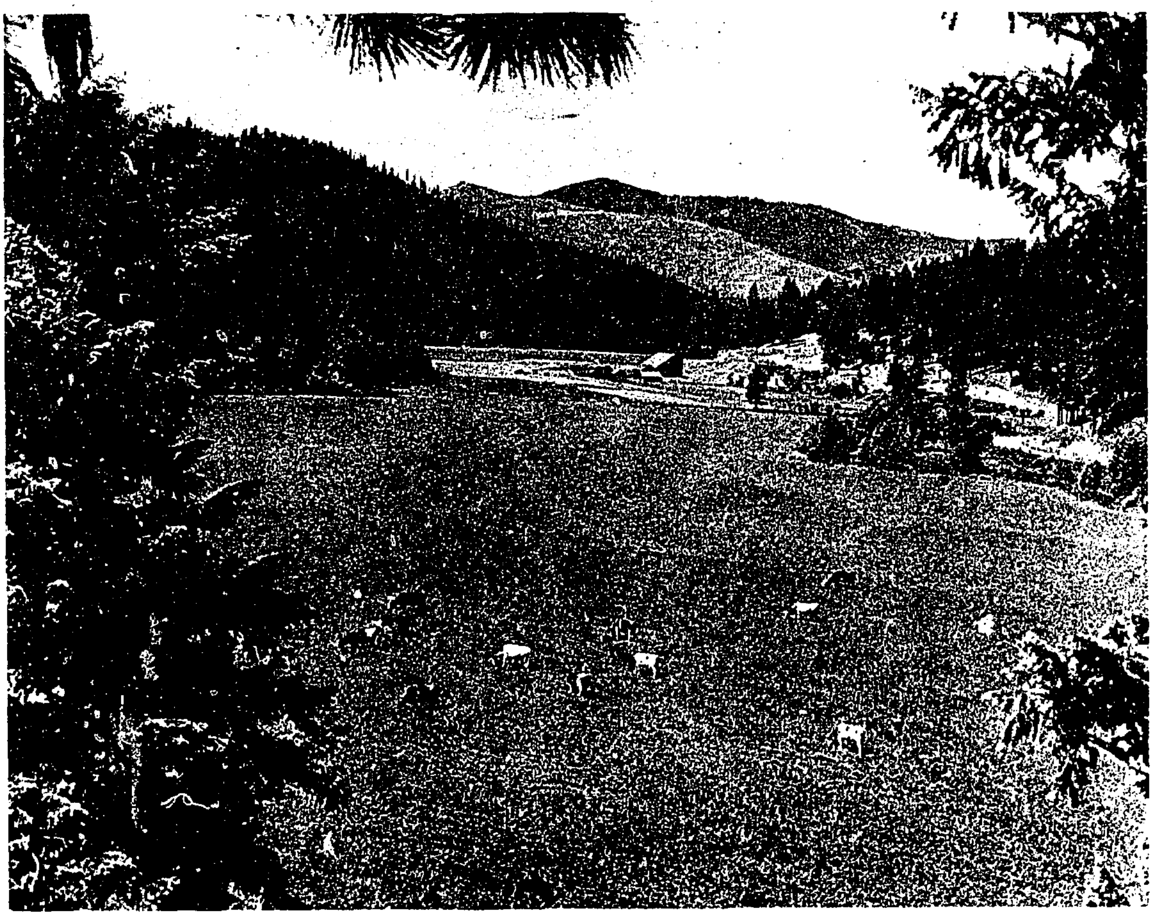
Different sources of food vary considerably in their chemical composition. Some foods are much higher in protein than others. Certain crops such as spinach and carrots are particularly high in certain vitamins. Therefore, the number of types of these various food commodities available may greatly affect whether or not people have an adequate diet.

Many plants that we raise for food are relatively inefficient compared to other plants that could be grown. Many of the plants used for food use only the seed of the plant. For example, with wheat, particularly in the United States, much of the straw is left on the field or possibly used as bedding. On the other hand, some leaf crops are almost entirely used for human food. As population increases, much may have to be done to improve the efficiency of plant use.

Man is unable to use as food many types of plant materials such as lignin and cellulose. Other materials, such as the leaves of many plants and seaweed, have not been widely used as human food. It is likely that many improvements in the processing of such materials will make them more palatable to man in the years to come. An interesting question to raise at this point is why man chooses what he does to eat.

Plants as Sources of Feed and Shelter

Through the process of photosynthesis, plants produce feed for all animals either directly or indirectly. Indirectly, some animals that eat plants are, in turn, eaten by other animals. The various species of animals have a wide range of preferences for certain plants or plant seeds, so they live in a large variety of feed habitats. Some animals have unique abilities to use various feeds. For example, the giraffe can reach to great heights to get its food, a cow can eat lignin and cellulose materials and digest it in its rumen (fig. 9), or a squirrel can crack nuts. Certain plants are more nutritious or help animals gain weight or produce milk faster than other plants. Also, as has already been mentioned, some plants, such as some grasses, can only be eaten by certain animals that can digest them.



USDA/SCS Photo

Figure 9.—Cows on pasture using forage to produce milk.

Animal feed must contain proteins, carbohydrates, minerals, fats, and vitamins. The correct amounts of these are obtained by mixing various materials to achieve the correct formula. Although some plants tend to be good feed for most animals, some tend to produce more efficient growth in only certain animals. Therefore, the types of plants that will grow in an area contribute substantially to the types of animals raised.

The types of plants raised also affect wild animals since they eat grains and other plant materials from farmers' fields and gain much faster than on most natural sources of food. Wild nuts, seeds, and berries often become very scarce at certain times of the year, so some farmers and other conservationists grow food for wildlife.

Not only do plants provide feed for animals, many kinds of plants also serve as cover or shelter for animals. Trees and brush may provide all the shelter animals need in most climates. Even piles of dead brush may serve as homes. A discussion of habitat can be found in the animal unit.

Plants as Sources of Fiber

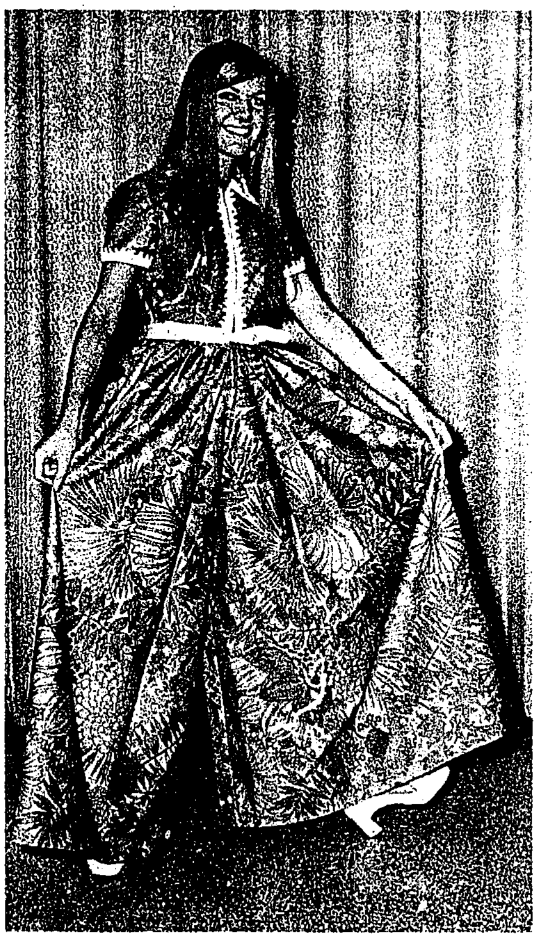
Many plants around the world are used as sources of fiber. Fiber is made from the stems or stalks, nuts, fruit, seeds, bark, and leaves of various plants. Cotton is a widely used plant fiber and is used extensively in making cloth. Although cotton can already be referred to as king of the natural plant fibers, much research is still being done to adapt it for new uses. The United States Department of Agriculture in its research labs has developed many processes to modify cotton to make it more useful (fig. 10). Cotton is now used for durable-press garments, water-resistant rainwear, rot-resistant awnings, flame-resistant uniforms and work clothing, and in soil-resistant garments.

Improved plant breeding has increased the types of fibers that can be produced from many plants. Some other plant fibers that are used include sisal, from sisal leaves, which is often used for twine; Manila hemp, which is often used to make rope; and jute and ramie, which are used for twine. Many fibers of various plants are referred to as hemp. Hemp fibers are used for twine, backing of carpets, upholstery material, cloth, bags, rope, and many other purposes. Flax is used to produce linen. Kapok fibers are used for insulation. Coir fiber from coconut husks is used to make door mats. Spanish moss, which grows in some trees in Southern States, is sometimes used for stuffing in upholstery work. Many other plant fibers are used for various purposes. Some of these are also mixed with synthetic or animal fibers for more versatility.

Some predictions have been made that plant fibers will become less and less important as more and better synthetic fibers are produced. Some of these synthetic fibers, however, require plant-produced materials in their production. Also, improvements are being made in varieties of plants that produce fibers as well as in processes to produce the fibers. There seems to be little doubt that plant fibers will be important for many years to come. It should be remembered that plant fibers are a renewable resource while some synthetic fibers are not.

Many wood products can be used as fibers and are a leading source of fiber for paper production. New production methods and improved species for pulp production are being tried.

Harvesting trees for pulpwood every 2 to 3 years—compared to the present 20 to 40 years—is a revolutionary new concept being explored by forestry scientists in Georgia. It holds promise of helping the United States and other nations meet growing needs for



USDA Photo by C. Embrey

Fig. 10.—Commercial wash-and-wear stretch cottons resulted from Government and industry research and development.

timber, pulp, and other wood-based products; and costs would be greatly reduced. The new system, called "silage sycamore," consists of planting sycamore trees at a very close spacing and then harvesting crops of sprouts with a silage cutter every 2 to 3 years. Time and space savings result compared to conventional wide-spaced tree plantations for pulpwood or other wood products, and higher yields of wood fiber per acre of land are expected.

The United States produces and uses paper and paperboard in fantastic quantities—in excess of 35 millions tons per year. Canada, the next highest producer, produces less than 9 million tons. The United States consumes over 425 pounds of paper and paperboard per person every year. There are about 7000 different kinds of paper. Many of them can be made from the same pulp with different processes.

Plants as Sources of Building Materials

The major building materials from plants are those derived from trees. Many fine building materials result from sawing logs directly into lumber or timbers. Particularly with higher priced woods, it is becoming more and more common to saw them into very thin sheets called veneers, which are used as a cover for thicker pieces of lower priced wood in plywood. Other building materials can also be manufactured from wood and wood products, such as pressed board and laminations (fig. 11). Many types of paneling and sheeting are also made using wood products. Wood continues to be in high demand as a building material. It is a renewable resource; concrete, steel, and other building materials are not.

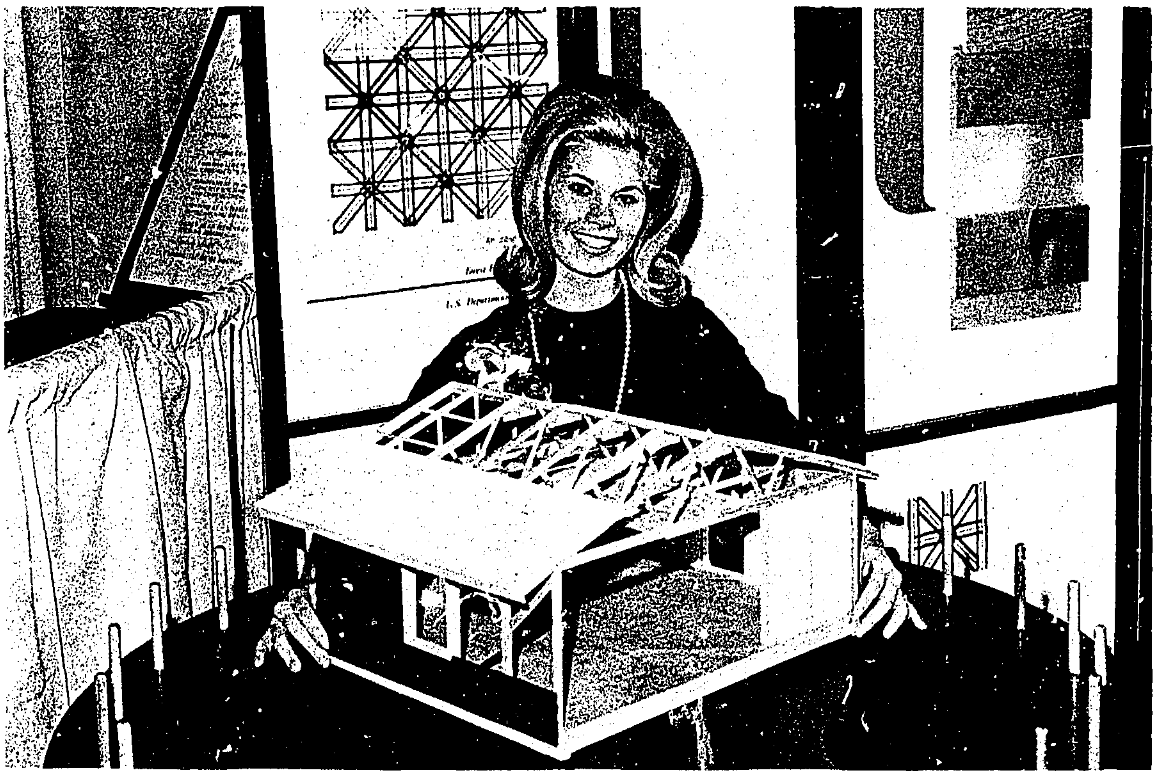


Fig. 11.—Model of experimental home built at Forest Products Laboratory. Costs are reduced by wood laminations, prefinished components, and modern adhesive compounds. Only a fourth as many nails are needed.

Other plant materials are also used for building purposes. Some plant fibers are used for insulation. Turpentine and linseed oil are used for painting. Plastics and other materials can also be synthesized from some plant materials.

Plants as Sources of Other Materials

Plants may be used in many other ways, such as for bay-rum, drugs, medicinal purposes, dyes, humus, flowers, flours, gun powder, maple syrup, perfume, resin, rosin, tar, rubber, and tobacco. Some of these materials, such as flours, are nearly a necessity for life; thers, such as flowers, make life more pleasant.

EFFECTS OF PLANTS ON THE ENVIRONMENT

Plants have both positive and negative effects on the environment. An effect may appear positive to one person and negative to another.

Esthetics

Plants add much in the way of beauty. Many kinds of plants produce beautiful flowers that often also add pleasant odors. Some families contain particularly beautiful or fragrant plants. The beautiful lily family contains the tiger lily, asparagus, tulip, and hyacinth, to name a few. The rose family, besides its namesake, which is often chosen as an example of beauty and fragrance, contains apricot, apple, blackberry, cherry, pear, peach, plum, raspberry, spirea, and strawberry. Many other plants with less showy flowers still act as important sources of beauty. Trees, shrubs, bushes, and other plants may increase the natural beauty of an area. Very important trees for many persons are the ones used as Christmas trees.

Many areas have developed very beautiful vegetation. Some of these areas are such as to have particular climatic conditions that allow rare species to grow. When such an area, which is often small in total size, is being threatened by industrial or other purposes, some people become alarmed. The large redwoods in California have been growing for hundreds and hundreds of years, but can be harvested or destroyed in a very short time. Thus, without caution, irreparable damage can be done to some of nature's handiwork. However, because redwood is valuable for many purposes, and redwood trees are very fast growing, with proper forest management they can make excellent production. Therefore, we certainly don't want to save all or even most trees as they can be harvested and new ones grown.

Improvement of Air, Water, and Soil

An extremely important byproduct in the process of photosynthesis is the oxygen given off by plants. This oxygen-producing ability that green plants have in the presence of the sun may make it advantageous to increase the number of plants in urban areas.

Many areas of the earth's surface have experienced one of the two extremes in water problems: flood or drought. Floods and drought are often the results of the misuse of soils or the lack of plant cover. With the lack of plant cover, rains may run off rapidly and erode soil rather than soak into it for use in dry periods. This rapid runoff may produce muddy water in nearby rivers and may be in such volumes as to cause floods. The rapid runoff, with its lack of penetration, may leave the soils in a droughty condition in a relatively short time. The lack of vegetation and the resulting flood and drought situation may have disastrous results on the soil since it can wash away in the flood and blow away in the drought. This is erosion, which is a natural process, but what we are talking about here is a matter of degree.

Many problems of an environmental nature can be partially corrected by good practices, many of which involve the planting of the correct type of cover (fig. 12). One problem that cannot be corrected entirely is prevention of stream bank erosion. It is estimated that stream bank erosion produces 500 million tons of sediment each year costing

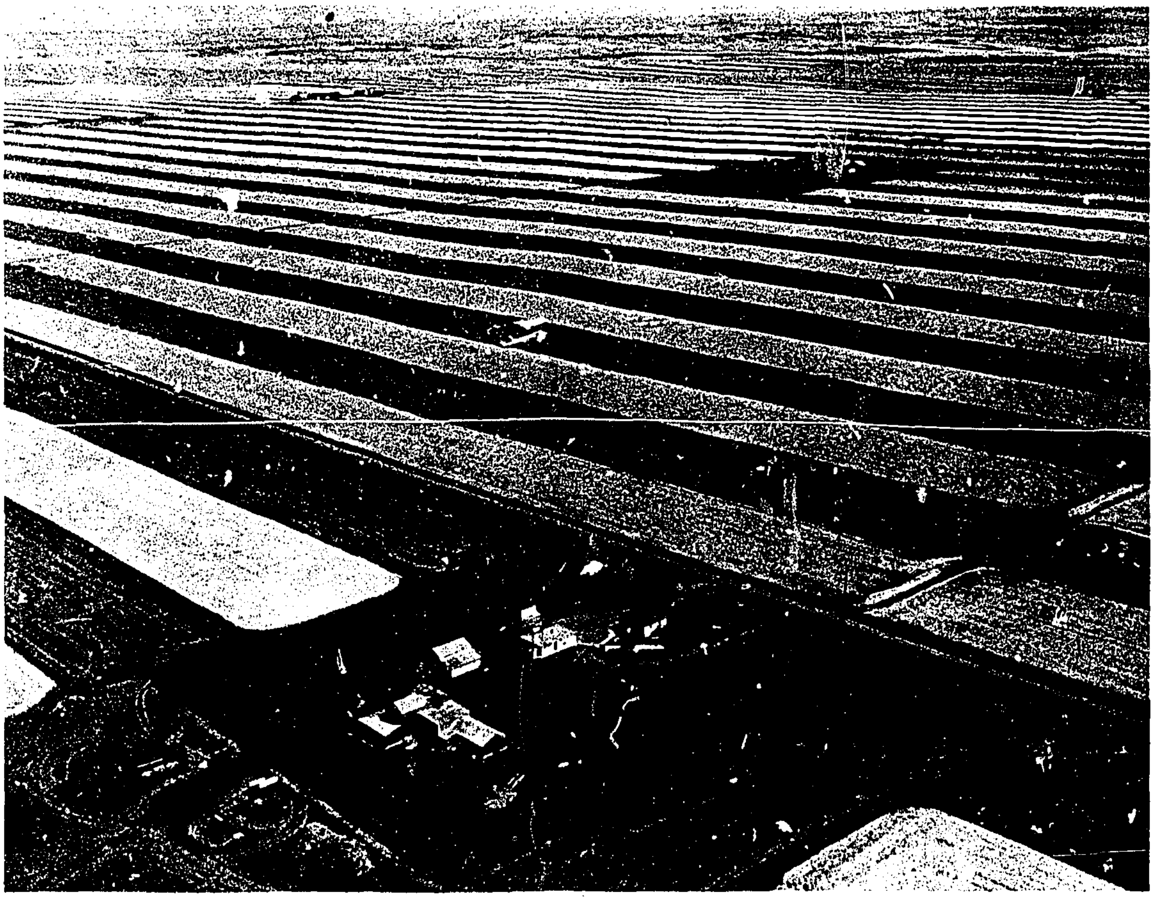


Fig. 12.—Strips at right angles to the prevailing wind help control wind erosion.

$250 million a year in removal costs from stream channels, harbors, and reservoirs. It is estimated that losses of land by erosion into nearby streams is valued at an additional $11 million annually. Correct planting of vegetation can considerably reduce stream bank erosion, and, combined with other protective bank covers such as rock riprap, concrete brush matting, and asphalt, may almost totally stop stream bank erosion (fig. 13).

Another important problem is that of surface-mined land. Over 3 million acres have been surface mined in the United States, and about 2 million acres of this have been left in a devastated condition. Much of this surface-mined land is causing sedimentation, soil erosion, water pollution, and is esthetically unpleasing. Much can be done to solve this problem with correct planting of vegetation (fig. 14).

There are well over 3 million miles of roads in rural America. Most of these roads require vegetation on the shoulders and where cuts or fills have been made. Soil surveys have provided valuable information to help determine the types of plants and ground covers to plant. Seedings along roadways in many States have been accompanied with better mulching and watering procedures in recent years. Plants that will do a good job of stabilizing roadside areas and also add to the esthetics of the area have been developed for use in many States. One such plant is crown vetch, which grows a pretty purplish flower and looks good through the summer without mowing.

Fig. 13.—With the bank sloped and the lower part protected by rock riprap (left), this section of Buffalo Creek in New York is being stabilized with vegetation. The costly effects of streambank erosion are illustrated (right) on a ranch in Washington where the Wenas River cuts away a strip of land.

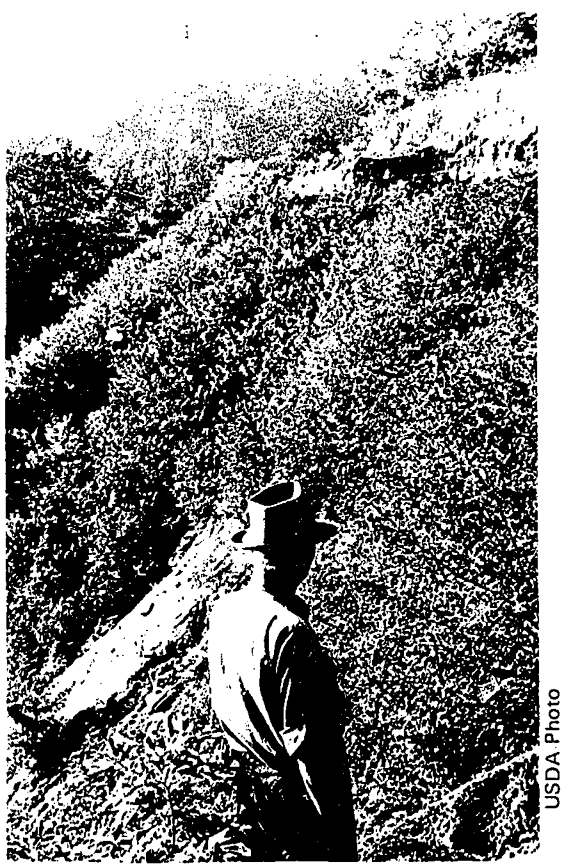


Fig. 14.—Plants improve even an ugly spoil bank left by strip mining.

Approximately 93% of the land in farms and ranches is now covered by one of nearly 3000 soil conservation districts in the United States. Each of these soil conservation districts is governed by a group of farmers. A farm conservation plan can be obtained by signing an agreement with the local district requesting help and agreeing to work toward better conservation practices. The local conservation district will then see that a soil conservationist from the Soil Conservation Service is assigned to make a farm conservation plan. The plan is made to fit the particular farm and the particular type of farming, including the likes and dislikes of the farm operator. Many farmers have improved their cropping procedures through a better knowledge of soil capability because of mapping by the Soil Conservation Service and a farm conservation plan map. The suggestions of the Soil Conservation Service have also helped many farmers to improve their farm conservation practices.

Some of the kinds of practices with which the Soil Conservation Service has been helping farmers include the disposal of animal wastes onto properly vegetated fields. Soil conservationists have also helped farmers lay out contour and strip cropping areas. Sod waterways have been established to help prevent erosion while helping to remove excess water. Some areas with extreme erosion problems have been planted to trees or other vegetation of a fairly permanent nature to help hold the soil in place. Farmers have been helped to establish farm drainage plans and to carry them out. A better understanding of correct grazing procedures has helped farmers to establish better pastures with increased grazing capacity while at the same time improving soil stability. Multiflora roses, often planted as hedgerows or fences, can effectively deter livestock and wildlife from removing vegetation from an area, thus helping to stabilize it. Another benefit often found with the planting of such species as the multiflora rose is the fine wildlife habitat it becomes.

Forests have long been recognized as an important part of the environment. In many areas, forests serve as very important watersheds. (A watershed is an area of land and water within the confines of a drainage divide or a water problem area.) As rain falls on a forest it first hits the top of the trees, referred to as the "canopy." Its force is thus diminished before it hits the ground. Some of the rain actually lingers on the foliage of the tree, and some of it drips off onto the organic forest floor. The organic forest floor, consisting of litter, fallen needles, leaves, twigs, and branches, helps soak up some of the moisture and makes it easy for some of the rest of the moisture to infiltrate into the soil. This organic cover also protects the soil in such a way as to develop a distinctive type of soil. Even with very heavy rains where considerable amounts of runoff result, soil erosion is cut to a minimum by the organic cover on the forest floor.

Careful selection of construction sites and removal of vegetation only from necessary areas can help prevent erosion. Rapid replanting after construction can reduce erosion and sedimentation problems.

Other forestry practices also have an effect on the environment. For example, clear cutting exposes more of a stream surface, so it can raise the temperature of the water.

Reduction of Noise Pollution

Many types of plants with their rather dense foliage can be used to help deaden sound. Vegetative growth along roadways or on the median strip on expressways can cut the traffic noise considerably. Plants are likely to be used increasingly to dampen sound as people become more aware of the damage being done to their hearing by excessive noise.

ENVIRONMENTAL PROBLEMS OF AGRICULTURAL PLANTS AND FORESTRY

Of the total wastes produced in the United States, agriculture and forestry contribute a share, but not an inordinate share. In fact, agriculture provides a prime means for amelioration or disposal of many wastes that might otherwise pollute the environment.

Production Efficiency and Economics

For many years, the price of agricultural products has remained relatively stable while the cost of producing them has increased dramatically, resulting in a cost-price squeeze. The cost-price squeeze, in turn, has forced farmers and foresters to increase efficiency. This has sometimes resulted in poor management from a conservation viewpoint.

Disposal of Plant Residues and Byproducts

Many plant residues, if left on the soil or worked into the surface of the soil, can act as a beneficial mulch and help to prevent wind and water erosion. On the other hand, the mulch may be detrimental to the production of the succeeding crop. Each year approximately 900,000 acres of grass are grown for grass seed. On each of these acres an average of 2 tons of residue is left. It is estimated that 300,000 acres of grass seed land is burned each year as a sanitation measure. This burning produces approximately 500,000 tons of particulate matter air pollution (fig. 15).

Fig. 15.—Disposing of plant residues can cause air pollution.

Some plant residues have possibilities for other uses, such as bedding for poultry and livestock, mulches, and for use in manufacture of corrugated cartons, insulating boards, etc. Washington was one of the first States to start research into the use of plant residues as mulches.

Leaving crop residues requires the correct supply of soil nitrogen, control of weeds, and the adaptation of a suitable cropping sequence. To avoid all this, straw from small grains has been burned in many areas. Large volumes of smoke and hydrocarbons produced by the burning of this straw have, in a few cases, been reported to reduce visibility and cause automobile accidents. This practice has been particularly common in high yielding areas where the straw is produced in such quantities that it cannot be readily worked into the soil or in especially good years in other areas. Attempts are being made to develop new varieties with shorter straw in hopes of preventing this problem without lowering yields. Other research is being carried on to try to find more effective uses for crop residues.

Disposal of forestry residues is also a major problem. Each year 25 million tons of logging debris are left in the woods. This material is an excellent breeding ground for diseases and insects. The ease with which this material burns also makes it a serious fire hazard. Forest fires that begin in logging debris are, on the average, seven times greater than those occurring in unlogged areas. These fires not only cause tremendous quantities of air pollution while burning and destroy numerous homes, but the uncovered land left behind results in excessive runoff, high levels of sediment, and increased flooding. However, mineral soil may be exposed thus allowing planted trees to grow very well.

It is obvious that some way needs to be found to dispose of logging debris to keep it from becoming a fire hazard. The only economically feasible way of disposing of large amounts of forest debris is by prescribed burning. The cost of eliminating debris by such burning is approximately $1 per ton (disposal by chipping costs about $12 per ton). However, not everyone is happy with prescribed burning. Some apple growers in the States of Washington and Oregon have filed suits against the United States Forest Service because they claim smoke from prescribed fires has prevented apples from coloring properly. Police in some Southern States have complained that smoke from prescribed burning has caused automobile accidents. The smoke from such fires also closes a number of airports each year.

It presently appears unlikely that an economically feasible alternative to burning for forestry trash disposal will be found. Therefore, it seems that research should be centered on improving burning methods and reducing air pollution from this practice.

Another problem is the deadwood that results from trees killed by diseases, such as Dutch elm disease, which needs to be destroyed to prevent the disease from spreading to healthy trees. Burning is often the best if not the only way to stop the spread of such diseases.

A different type of problem is that the processing of forest products also produces large quantities of wastes. Most of these wastes are organic in nature. These processing wastes amount to nearly 400 million cubic feet of logging residues and 230 million cubic feet of coarse wood residues each year at manufacturing plants. Great improvements in the forest products industry have been made, so this waste is being cut drastically. Sawdust and wood chips, which were once basically waste products, are now often used to make such products as fireplace logs (fig. 16). Some of these same materials are used for making pulp. The future looks bright in developing new uses for forest waste products.

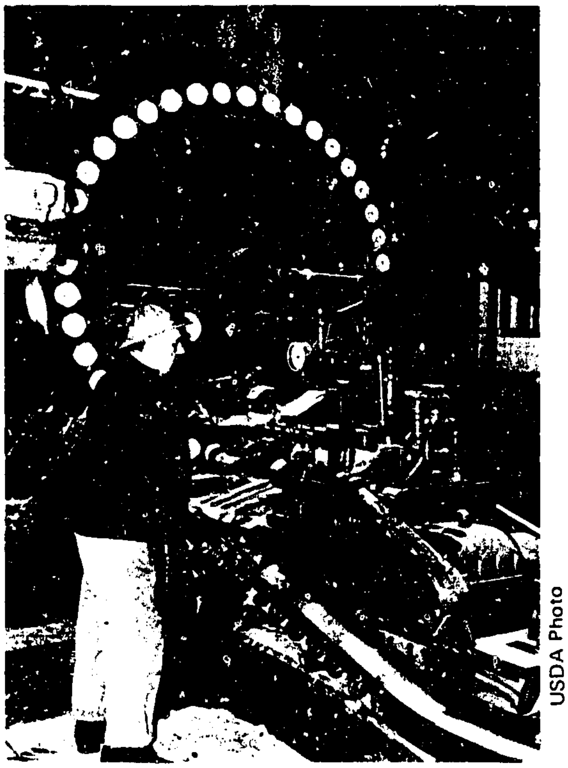


Fig. 16.—Sawdust turns into fireplace logs at Longview.

Processing of agricultural products also causes many problems. The processing or harvesting of many grain or forage crops produce large quantities of dust. The processing of many types of food products, including vegetables, requires large quantities of good quality water. A considerable amount of organic matter may be added to the water.

Many of the present processing plants were established at a time when less emphasis was being placed on water consumption, so they dump large quantities of effluents into streams. These plants are being studied for ways in which the water can be reused and effluent reduced. It has been found that some of the water can be used for irrigation. Also, many processing steps can probably be improved so as to cause less disposal of waste materials. Already, harvesting of many crops has been changed so as to leave many materials in the field that were formerly waste products at the plant. Some of these wastes on agricultural land can be used for other purposes.

When plant residues are disposed of on land, the breaking down of these organic materials may require considerable nitrogen, thus tying up its use from the soil for the next crop, unless additional nitrogen fertilizer is applied.

When plant residues become wet or are dumped into water, they may require so much oxygen to decay that they deplete the oxygen completely and anaerobic bacterial activity starts. This causes both odor and esthetic problems. After the oxygen is depleted to this point, much of the other life in the river will have already been killed, spoiling the water for recreation or fishing purposes.

Plants and the Use of Agricultural Chemicals

Increased economic pressure has caused many farmers to further specialize their operations. Increased specialization has often been followed by increased populations of insects and diseases. Although improved varieties have helped to overcome many types of diseases and infestations of some insects, specialization has often been accompanied by increased pesticide use.

Increased productivity and the ability to produce better quality products has come through the use of pesticides. Many of these pesticides have far-ranging effects and may kill or damage things other than those for which they were intended. The use of pesticides has come under sharp criticism by many people. Too often agriculturists have replied that, although some minor damage may be done through the use of pesticides, starving millions have actually been saved by their application. Although this statement is true, and obviously saving lives is a lofty aim, such a reply does not answer the question as to how much harm is being done by the pesticides. Since some of the important damage that could be being done by pesticides may be by relatively low levels of exposure over long periods of time, much more research needs to be done to give exact answers. Presently, not enough is known about the long-term effects of many pesticides to accurately predict their effects under all possible conditions. Chemicals are, however, tested and registered for each use so that dangers can be kept to a minimum.

Properly used pesticides have resulted in great benefits to man. The question here, however, is not how much benefit has been derived from the use of agricultural chemicals but rather how much damage has been done by them. Most experts seem to agree that, when properly used, agricultural chemicals have resulted in benefits much outweighing any harm. On the other hand, when misused or used carelessly, they have caused considerable harm. The USDA and other departments, agencies, and universities have worked to attain the goal of safe pesticide use (fig. 17).

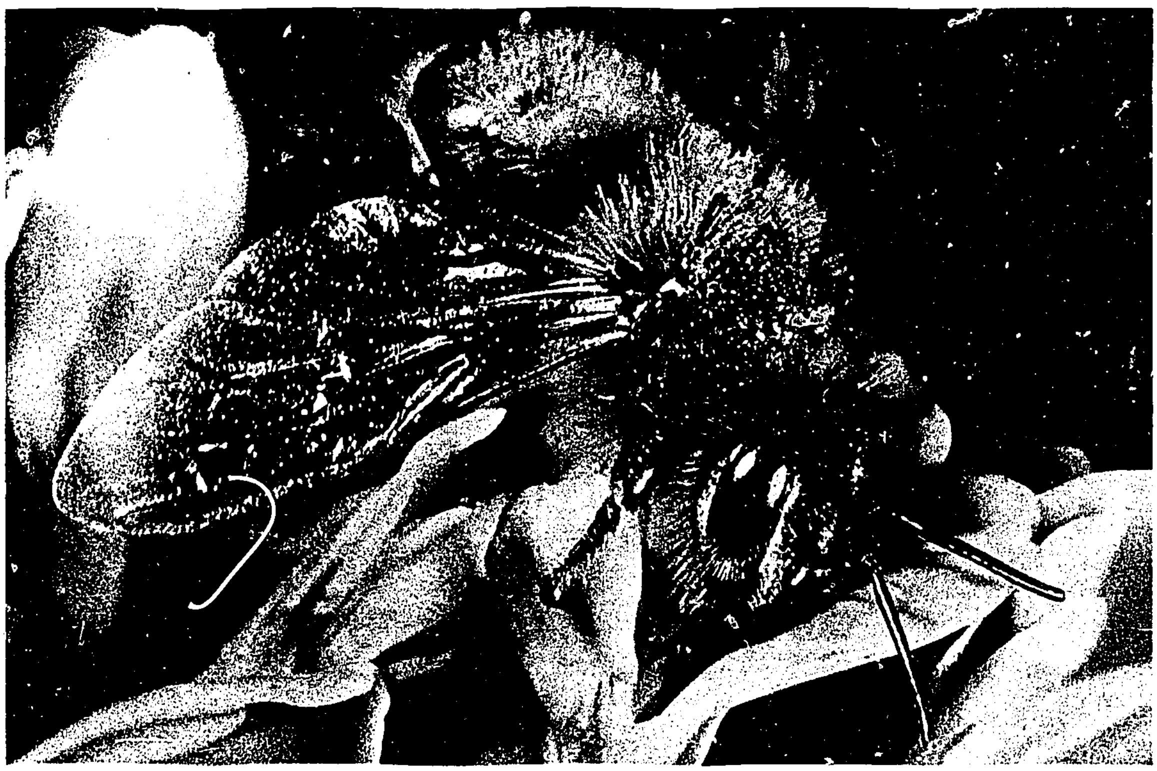
The use of agricultural chemicals continues to increase at about 15% per year. In 1969, about 1.2 billion pounds of synthetic organic pesticides were produced in the United States. About 20% of these were exported. A little over half of the pesticides are used in farming. Much of the increase in total pesticide use has been due to increased use of herbicides.

Insecticides are probably the most important group of pesticides as concerns the environment. This is due to the fact that insecticides are materials that are highly toxic to insects (fig. 18). Many of these highly toxic materials are not highly selective as to the type of life that may be damaged. Some of these insecticides are very persistent. That is, they tend to break down very slowly and so continue to have an effect on the environment for a considerable period of time. This may also make them more useful or less expensive. Some of these insecticides may also affect reproduction in birds, even at fairly low levels of residues in their tissues. The persistent chlorinated hydrocarbon insecticides are one of the most discussed groups of chemicals. They accumulate in animal tissues. Many of these have low toxicity to humans.

DDT is a chlorinated hydrocarbon. Its residues have been found in soils and also in the tissues of man, fish, wild animals, and birds. The importance of these residues at the levels at which they are found has not been established. DDT residues have been found to exceed 100 pounds per acre in some orchards. Varying levels of residues of other insecticides, such as Endrin or Dieldrin, have also been found in both crops and soils. Nine hundred milligrams of DDT-derived materials is the average carried in human body fat in the United States. This figure seems to have remained relatively constant for the past several years. Most experts

Source: National Agricultural Chemicals Association

Fig. 17.—Symbol developed by USDA to encourage safe and effective use of pesticides.



USDA Photo

Fig. 18.—Insecticides may kill nontarget insects like this bee.

consider these levels to be of no significance to health. The . bility of pesticides (DDT, for example) to be stored in fat and body tissues appears to be an even more important problem. The problem is that biological magnification of residues in the tissues of other animals occurs. This happens when organisms containing an accumulation of DDT are consumed by fish, birds, or other animals. The more these DDT-containing organisms are consumed, the higher the DDT content may become in the consuming organism. Although the accumulation of DDT may not be serious to the organism being consumed, it may produce highly toxic results in the organism that consumes it. For example, earthworms living in DDT-contaminated soil and then eaten by robins may kill the robins.

Another important group of materials is fungicides. Fungicides form a group of materials used to destroy or control fungus. Since these materials generally are not highly toxic, the danger of water pollution contamination by them has been considered to be very insignificant. However, recent scares about certain heavy metals such as mercury and copper, both of which are used as fungicides, are causing increased research. Mercury has been used quite widely as a seed treatment. The amounts put on the seed are relatively small. It is, however, thought that even these relatively small amounts may be highly detrimental since many fish and other aquatic life have been found to contain relatively high levels of mercury. The high concentrations of mercury found in some fish are likely due to biological magnification. Natural levels of mercury in ocean waters have not been determined.

Another group of agricultural chemicals that may cause water pollution is herbicides. This group of chemicals may have very serious indirect water pollution consequences. For example, certain herbicides control almost all vegetative growth. In fact, the soil may be sterilized by use of certain herbicides. The resulting sterilization and lack of vegetation may in turn cause considerable erosion. This erosion may wash both the herbicides and silt into surface waters causing severe water pollution problems.

The use of herbicides for the control of aquatic weeds is subject to regulation and restriction just as with all other chemicals. No organic herbicides are registered for use in reservoirs or lakes used for drinking water. A few herbicides are registered for use in irrigation water. Control of aquatic weeds in water used for irrigation improves the ability of the water to be moved. Many common herbicides used at proper levels to control most submerged aquatic weeds do not injure fish. The same materials at higher rates may become toxic to humans, fish, livestock, wildlife, and crops. Some of these materials will injure only certain fish. For example, copper sulfate will not normally injure bass, bluegills, and certain other fish but may be highly toxic to trout at concentrations necessary to control algae.

Nematocides are a group of materials used to control nematodes. Some of the major nematocides presently in use are the halogenated hydrocarbons, carbamates, and organophosphates. Runoff from fields treated with nematocides or irrigation water that has had nematocides added to it are potential hazards. Chlorine and bromine residues persist in soil treated by certain nematocides. The amount of runoff from soils that have had nematocides applied to plants growing on them has not been determined to date. At this time no immediate health hazards are apparent.

Plant Nutrients

One method of increasing plant productivity is the application of plant nutrients. Although many improvements in the environment may be made by correct application of plant nutrients, some undesirable characteristics may also accompany this application. The increased yields and plant growth may also increase plant residues, thus causing high accumulations of straw after harvesting of small grain crops. As this straw accumulates in greater quantities, disposing of it may become a difficult problem. Many farmers have felt that the heavy accumulations of straw require burning to prepare for the next crop. The burning, in turn, produces large quantities of air pollution.

In 1966, Americans applied 32 million tons of chemical fertilizers. These fertilizers were applied to lawns, gardens, orchards, fields, forests, and pastures. This seemingly large tonnage of commercial fertilizers is often blamed for the adverse effects of plant nutrients in surface water. Actually, the largest source of plant nutrients in water is municipal sewage.

The United States has not been economically pushed to use plant nutrients in the high volumes used in some other countries. For example, in the Netherlands in 1965, there were 11 times as many pounds of nitrogen per acre applied as in the United States. In that same year, there was 5.8 times as much phosphate applied and 8.9 times as much potash (K_2O) per acre as in the United States.

Two major concerns arising from plant nutrients in water are nitrates in drinking water and eutrophication of lakes and streams. It has been known for a long time that nitrate moves into ground water. It may also be carried into surface water. At the same time, some lakes and ponds have too little nutrient content to support good fish growth.

A major source of nitrate pollution is from sewage. However, agricultural production also contributes to the problem of nitrate pollution. Nitrates themselves are not particularly dangerous. However, when certain bacteria are present in the digestive tract, nitrates can be converted to nitrites. Nitrites are highly toxic. Nitrates may also be turned to nitrites in open containers of food and in certain types of feed.

Babies and farm animals are most likely to include in their digestive tracts the types of bacteria and other conditions that help to convert nitrates to nitrites. The oxygen-carrying pigment of red blood cells is reacted with when nitrites are absorbed into the blood stream. In this process, methemoglobin is formed. This material does not have the ability to transport oxygen like normal hemoglobin. If enough of the nitrite is absorbed in the blood stream, methemoglobinemia takes place. This disease is often referred to as "blue baby" since infants turn particularly blue because of the lack of oxygen. Methemoblobinemia is characterized by labored breathing and in extreme cases may terminate in suffocation. The importance of methemoglobinemia can be readily seen by the fact that 139 cases were found in Minnesota from 1947 to 1950. Fourteen of these cases resulted in the deaths of the infants.

Agriculturists are large land users raising agricultural crops and forest products. With an operation of the size carried out by American agriculture, it is little wonder that some complaints arise. Also, since many persons are involved in the production and processing of the huge quantity of products it seems rather natural that, as in other businesses, there are a few unscrupulous operators. Unfortunately, many persons discussing the damages being done to the environment use the extreme cases of a few of these unscrupulous operators for examples of what is being done. They often imply that these practices are being widely used throughout American agriculture. On the other hand, such men as Gifford Pinchot and his work in American forestry are seldom mentioned, nor are the many agriculturally oriented conservation groups that have done so much to preserve the American landscape.

Sediment

The volume of sediment reaching U.S. waters is in excess of 700 times that of total sewage discharge loadings. Sediment is carried off in runoff from cropland, unprotected forest soil, overgrazed pastures, and other land areas. Total sediment production in the United States amounts to approximately 4 billion tons a year (fig. 19). The amount of sediment per square mile varies considerably with the section of the country. Also affecting the amount of sediment are such factors as soils, geology, topography, precipitation, conservation practices, and vegetative cover. It has been shown in experiments across the country that sediment can be reduced through the use of good conservation and the right kind of vegetative covers.

USDA Photo

Fig. 19.—Sediment fills reservoirs.

Clay soil particles hold several times the amount of phosphorous adsorbed by natural soil. Therefore, the higher the percentage of clay particles a soil contains, the greater its ability to adsorb phosphorous. Consequently, more phosphorous may be washed into streams by soil erosion.

Soil particles hold tightly onto phosphate molecules. Even when fine soil particles that have thousands of parts per million of phosphorous on their surfaces are suspended in a river, only 0.005 to 0.0005 part per million of the phosphorous may truly become phosphorous in solution. Therefore, water samples should be analyzed in a way that will measure the amount of phosphorous in true solution. However, when aquatic plants are growing in sediment, the problem becomes much more difficult. Their roots may remove some of the phosphorous adsorbed on soil particles.

SOCIOECONOMIC EVALUATION

Many determinations of the present situation need to be made. Questions such as the following will have to be answered. What is a quality environment? How much contamination is acceptable? How much are we willing to pay to improve the environment? What kind of waste treatment do we want? Who should set standards and what standards should be set? How should these standards be enforced? How do we evaluate whether a satisfactory environment is being achieved? Can we decrease the rate at which population is increasing? If we cannot decrease the rate at which population is increasing, must we use chemicals and fertilizers to increase crop production to feed the increased population? How many of the problems involving the environment can be solved with education? What areas need governmental action such as new laws and better enforcement? How many of the present economic benefits are we willing to give up to help improve the environment? What are the conflicting points of view? How will other groups be affected?

Once the above and other similar questions are answered, decisions can be made that should satisfy the majority of the citizens. As these questions are answered and decisions are based on better information, it is likely that a balance will be achieved between social and economic solutions to problems. This is obviously going to be very difficult and time consuming.

Many facts are available. The need for food production and increased population are connected. Famines and undernourishment are taking place at the present time. While there is a need for nonpolluting food, there is a need for food whether or not it is polluting. Thus, our goal is to produce food while improving the environment.

Studies have been and are being carried on to obtain information that will help answer many of the important questions. The Pesticide and General Farm Survey for 1966 is an example of an in-depth survey of thousands of farmers in the continental United States. Comparing data from one survey to another can help determine trends.

A LOOK TOWARD THE FUTURE

Increased regulations will likely establish what will be planted where and under what conditions. More restrictions are likely to be placed on areas that are steeply sloping. Strip cropping may even be required on gently sloping areas that run for great distances. Laws and zoning ordinances may designate greater areas of land for specific uses.

Rapidly dwindling supplies of many natural resources, such as coal, oil, and gas, will necessitate uses of other materials. Some of these will likely come from plants. Since plants are a renewable resource they will be more widely used.

An increased emphasis will be placed on obtaining maximum efficiency from green plants. We may find more emphasis placed on using existing but unused plants such as algae. New ways of using and growing plants will doubtless be developed. More complete utilization of plant residues will be required, including their possible use for production of energy.

New varieties of plants that produce higher yields, less waste, and increased quantities of higher quality nutrition will likely be developed (fig. 20). Plant practices will be developed that will also help improve crop production.

Fig. 20.—New varieties can increase production.

As the human mechanisms for taste are better understood, many changes will likely result. Artificial flavorings and texturing will become more common as chemicals and other means will be used to change the desirability of foods. It is very possible that a family of the future will sit at a table with a bowl full of potatoes and several small containers of chemicals that each will add to the potato until it pleases his or her taste.

Research into the many problems that presently face us will continue, and many answers will be found. However, some of the problems are basically social problems, and human action of a different type will be required to solve these. One of the greatest problems facing us is the limitation of our increasing population. The actions that will be taken to keep population in line with food production remain to be seen.

SUMMARY

The environment has a considerable effect on the ability of plants to grow in a given area. There are many ways in which the environment can literally destroy a crop. All life depends on photosynthesis for the production of food. Since plants are the vehicle through which photosynthesis occurs, plants are necessary for life. Plants also serve as important sources of feed, seed, and fiber. Many types of plant materials serve for decorative and ornate purposes as well as for construction purposes. Although plants are presently being used in many ways, it seems obvious that even more uses will be found for them in the future.

Plants will continue to exchange oxygen for the carbon dioxide that they take in. There is little doubt that plants will continue to play an extremely important role in control of soil erosion.

Research needs to continue on the use of plant residues to find additional ways that some of these materials can be used. For those residues for which new uses cannot be found, better methods of disposal will have to be developed. Helping to overcome some of the plant production and residue problems may require larger sums of money from the Federal and State Governments. It is likely that the solution of many of the problems will require more than the individual operator can afford. It is likely that weeds will continue to be an important problem with which to contend in raising plants commercially. Plant diseases and insects will also likely continue to be a serious problem. Improved plant disease and insect control can be expected from improved technology. However, this may be counterbalanced by the problems created in these areas through continued specialization of cropping.

BIBLIOGRAPHY

Breetveld, Jim, *Treasure of the Timberlands*, Scholastic Book Services, New York, 1970.

Brown, George W., "Predicting the Effect of Clearcutting on Stream Temperature," *Journal of Soil and Water Conservation*, January-February 1970.

"Capsule Forestry," Society of American Foresters, Portland, Oregon, 1966.

Clawson, Marion, "A New Policy Direction for American Agriculture," *Journal of Soil and Water Conservation*, January-February 1970.

Council on Environmental Quality, *Environmental Quality: The First Annual Report of the Council on Environmental Quality*, Government Printing Office, Washington, D.C., 1970.

——, *Environmental Quality: The Second Annual Report of the Council on Environmental Quality*, Government Printing Office, Washington, D.C., 1971.

Dunham, R. S., *Introduction to Agronomy*, The Dryden Press, Inc., New York, 1957.

"Growing Trees in a Growing Nation," American Forest Products Industries, Inc., Washington, D.C., 1967.

Hagenstein, W. D., "Emotions Aside, Clearcutting is Silviculturally Sound Concept," *Forest Industries*, December 1970.

Hall, J. Alfred, *Wood, Pulp and Paper, and People in the Northwest*, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, 1970.

Hine, Quentin A. and Norman K. Hoover, *Management of Forest Resources for Multiple Use*, student resource unit and teacher's guide, The Pennsylvania State University, University Park, Pennsylvania, 1970.

Hornbeck, J. W., "Protecting Water Quality During and After Clearcutting," *Journal of Soil and Water Conservation*, January-February 1968.

Journal of Soil and Water Conservation, March-April 1971.

Krebs, Alfred H., *Agriculture in Our Lives: An Introduction to Agriculture and Agricultural Science*, second edition, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1964.

"Our Forest Bounty," American Forest Products Industries, Inc., Washington, D.C., 1968.

"Pacific Northwest Range: Its Nature and Use," PNW bulletin 73, A Pacific Northwest Cooperative Extension Publication.

"Steppe Vegetation of Washington," technical bulletin 62, Washington Agricultural Experiment Station, Pullman, Washington, 1970.

"There's Trouble in the Woods," Northwest Forest Pest Action Council, Portland, Oregon.

U.S. Department of Agriculture, "Grass," *Yearbook of Agriculture, 1948*, Government Printing Office, Washington, D.C., 1948.

——, "Grass Waterways: In Soil Conservation," leaflet 477, Government Printing Office, Washington, D.C., 1966.

——, "Protecting Our Food," *Yearbook of Agriculture, 1966*, Government Printing Office, Washington, D.C., 1966.

——, "Science for Better Living," *Yearbook of Agriculture, 1968*, Government Printing Office, Washington, D.C., 1968.

——, "Treatment of Critical Erosion Sites," Soil Conservation Service, Hyattsville, Maryland, 1970.

——, "Trees," *Yearbook of Agriculture, 1949*, Government Printing Office, Washington, D.C., 1949.

U.S. Department of the Interior, "For the Benefit of Man," published by the Bureau of Mines for the White House Conference on Natural Beauty, Bureau of Mines, Washington, D.C., 1965.

——, "Making Multiple-Use Decisions," Government Printing Office, Washington, D.C., 1970.

Wadleigh, Cecil H., *Wastes in Relation to Agriculture and Forestry*, United States Department of Agriculture, miscellaneous publication 1065, Government Printing Office, Washington, D.C., 1968.